# From Lyngby to Launch and Beyond

34 years of XMM

Study Scientist, Mission Scientist,
Project Scientist, Users group member,
GOF director, researcher, thesis
advisor and survivor

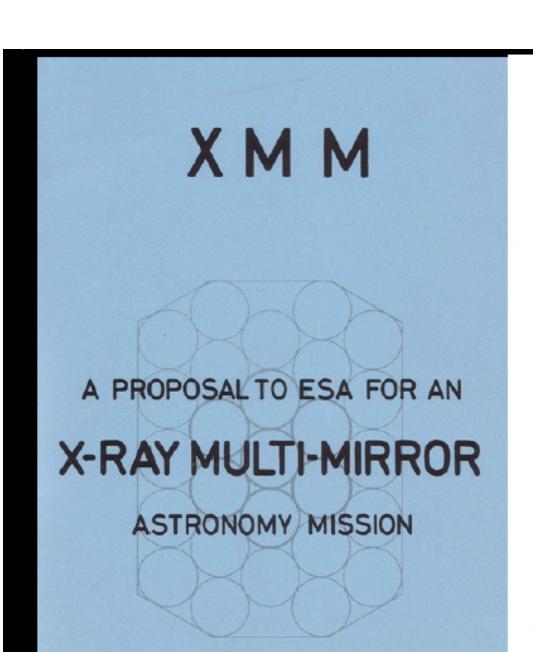
I will stress the journey and not the science

#### Before the Beginning (I was not involved)

- Nov 1982.(XMM: A proposal to ESA for an X-ray' Multi-Mirror'
   Astronomy Mission, J.A.M. Bleeker, A.C.Brinkman, J.L. Culhane, L.
   Koch, K.A. Pounds, H.W. Schnopper, G. Spada, B.G. Taylor and
   J.Trumper, Nov 1982
  - 7 high energy telescopes, with 30" HEW and 0.5m<sup>2</sup>,
  - 20 low energy(LE) telescopes with 10" HEW and 1m<sup>2</sup>. The mirror technologies encompassed foils, diamond turning and replication -
  - Every form of detectors: PSCPs, GSCPs, MCPs, CCDs, crystal spectrometers, transmission and reflection gratings etc.
  - A low-earth orbit with a Shuttle launch

 Horizon 2000': envisioned an x-ray cornerstone "A High Throughput X-Ray Mission for Spectroscopic Studies between 0.1-20Kev" launch in

early 2000 (!!)



#### Submitted by

J.A.M. Bleeker, Leiden
A.C. Brinkman, Utrecht
J.L. Culhane, MSSL
L. Koch, Saclay
K.A. Pounds, Leicester
H.W. Schnopper, Lyngby
G. Spada, Bologna
B.G. Taylor, SSD/ESA
J. Trümper, Garching

through

J.L. Culhane Mullard Space Science Laboratory Holmbury St. Mary Dorking, Surrey, England

Telephone: 306-70292 Telex: 859185

November, 1982

## The Lyngby Worskhop

I attended (and presented a paper "X-ray spectroscopy of active galactic nuclei.")

This was the genesis of the XMM mission June 1985

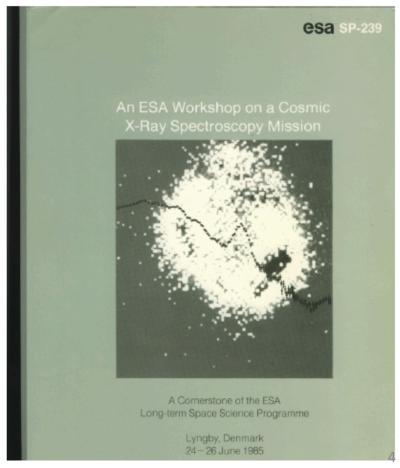
ESA Space Science Horizon 2000.

4 Cornerstone Missions.

Cornerstone #2: High Throughput X-ray Spectroscopy.

Cost/Cornerstone =1.5 X ESA's Science Budget

Complementary with AXAF.



#### **esa** sp-239

#### An ESA Workshop on a Cosmic X-Ray Spectroscopy Mission



A Cornerstone of the ESA Long-term Space Science Programme

> Lyngby, Denmark 24-26 June 1985



90

JAM BLEEKER

The prime design drivers for a high throughput spectroscopy mission can, therefore, be summarised as:

= Energy dynamic range: 0.2-10 keV, covering the bulk of the
emission in the X-ray band
throughput optimised for the 2-8 keV band:

\* A<sub>eff</sub> \ge 10.000 cm<sup>2</sup> at 2 keV

\*  $A_{eff} \ge 5.000 \text{ cm}^2 \text{ at 8 keV}$ 

= Angular resolution: requirement ≤ 30 arcsec HPW at 7 keV design goal 10-20 arcsec HPW at 7 keV

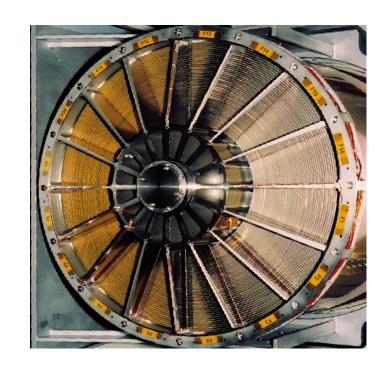
This provides a dramatic increase of collecting power over the AXAF mission of about 10 at 2 keV and 30 at 8 keV at the expense of angular resolving power.

### Lyngby and next step

- 47 Talks: the scientific community expressed its view on the science of XMM and to identify the drivers in the payload development.
- Serious work on XMM started in 1985 with the establishment of a number of XMM working groups (Science, telescope and science) and the conduct of a 'Phase A' industrial study
- SAG members
  - Bergeron, J., Bleeker, J., Gabriel, A., Mushotzky, R.,
     Pallavicini, R., Paradijs van, J., Peacock, A., Pounds, K.,
     Schnopper, H., and Trümper, J.
  - RM was the only American.

## The Very Early History of XMM

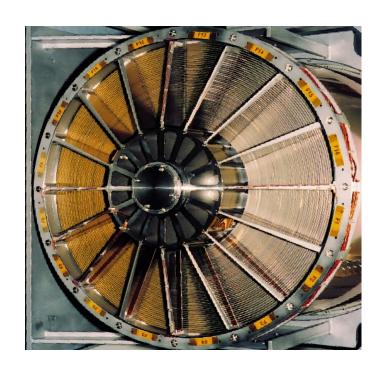
- June 3 1986- First meeting of the XMM 'Science Advisors'- not 20 years but 33
- R. Bonnet (DSci)
  - Cornerstone is a 'new' trend in ESA; high throughput X-ray mission
- -Cost limited at 400MAU (+nation states of 150MAU) (pre-Euro)



Complementary to AXAF (Chandra)
Couple the two together for a
major breakthrough in
astrophysics
Telescope is the major cost and
schedule driver- must design to
cost - best and cheapest
Size - cost Ariane -IV launch

## The Very Early History of XMM

- Original chair was Alan Gabrielhis charge
- 400MAU is not a big sum
- Need to be single minded
- This will be a difficult road
- Need cohesiveness of the community
- Must make compromises, convince enemies
- Lyngby kick-off meeting: good from science point of view
- Bad from recommendation pt of view (too complex)



#### Before the Beginning- the SAG RM letter to Roger Bonnet Director of Science

 At the time of the Teneriffe meeting I agreed with Dr.X that it appeared that many of the basic decisions about XMM had been made before the SAG even met. However, after talking extensively with Dr. Peacock about this I think I understand the reasons behind the timing. I disagree with Dr. Peacock as to the necessity of <u>rapidly</u> reaching conclusions about the telescope and the launch vehicle. However, I do think that his reasons were logical and sensible and that it was necessary to reach conclusions in a timely fashion. It was, however, not the best way to start the SAG.

## March 1988, the XMM Mission Science report-Major Change in Mission Design

#### RM a co-author

- An Ariane 4 launch a 24hr period orbit,
  - 'model' payload -3 mirror modules , using replication technology,
    - 6000cm<sup>2</sup> at 2keV and 3000cm<sup>2</sup> at 7keV resolution of <30" HEW.</li>
    - Each mirror module has a CCD camera and two with reflection gratings.
    - complimented by the Optical Monitor.
    - ESA's Scientific Programme Committee (SPC) approved the mission in June 1998 and the AO for the instruments was released the same month

## Mission Scientist and Project Scientist

- In 1988 ESA had a call for mission scientists and selected 2
   Americans (Rich Griffiths and myself)
- To 'save money' the director of astrophysics at GSFC then selected me to be the U.S. project scientist.
  - performing the triple role of mission scientist, representing NASA and the U.S. community and setting up and 'running' the US guest observer program this was not easy
- thanks to the efforts and foresight of France Cordova (OM) and Steve Kahn (RGS) the US had major participation in 2 of the 3 instruments.
- I was (nominally) responsible for oversight of the US contributions.

#### Applying to be mission scientist 1988- quotes from proposal

- I hope to contribute to the XMM project in the following ways:
- 1) To keep abreast of new scientific developments from the x-ray missions of the 1990's and other observational and theoretical progress so that XMM can best address the scientific problems of importance in the time frame in which it will be operational. This is best done by actually being involved in the preparation, operation and scientific analysis and interpretation of the data.
- 2) To give "unbiased" advice on the technical/scientific tradeoffs that will have to be made in the course of designing and constructing the observatory so that the best science can be done commensurate with the technical, financial and schedule constraints that ESA will find it necessary to impose.....
- Since the XMM observatory will be a long lifetime observatory it is necessary that its design be as flexible and powerful as possible, consistent with the technical and financial restrictions, and that it and AXAF will be as complementary as possible.

#### Mission Scientist

Mission scientists
Jacqueline Bergeron
Richard Griffiths
Richard Mushotzky
Roberto Pallavicini

Telescope Scientist Bernd Aschenbach





### Typical SWG Meeting 2 Days

Agenda For XSWT Meeting Number 20: 14/15 February 1996  14 February 1996: Morning ===================================		14 February 1996 : Afternoon		
		7) The Calibration Facilities Available to XMM a) The CSL Facility H/W Characteristics, Capabilities, Activity to be performed, Limitations, Schedule PG		
				<ul> <li>2) Progress Report Reviews - Quality</li> <li>a) Mission/Spacecraft</li> <li>b) Mirror &amp; Metrology State</li> <li>c) Telescope Scientist Report</li> </ul>
•	IS Experiments K-Gendreauns Performed ramme	8) The XMM System Calibration a) Overview of System Calibration b) Unit Level Calibration of Mirror c) Unit Level Calibration of EPIC MOS MJT d) Unit Level Calibration of EPIC PN e) Unit Level Calibration of RGS JWH f) Unit Level Calibration of OM	DL DL PG/TS GFB/ GFB/CR BB/SK/ KOM	
around f) Summary of "do's and don'ts" for XMM 6) Progress Report Reviews - Question/Answer Session a) OM Report b) EPIC Report C) RGS Report BB		g) The System Level Calibrations at Pa h) The EQM Programme . Logistics . Hardware . Time Lines	anter DL DL	

#### And So Forth for 11 years

- We typically has 2-4 meetings per year and there were many issues
- In the early years there were great worries about the optics since they were the technical drivers.
- In later years there were lots of discussion about the PV phase, how the mission would operate, data policies etc etc.
  - I failed to get a uniform policy on the PV phase which would have involved the PIs collaborating
- Last SWT meeting Jan 23,2001

#### 3 Missions at Once

- I was a interdisciplinary scientist for AXAF
- A member of the ASCA/ AstroE1/Suzaku science team as well as
- XMM Mission Scientist
- XMM Project Scientist

FAX TO T. Peacock 1992

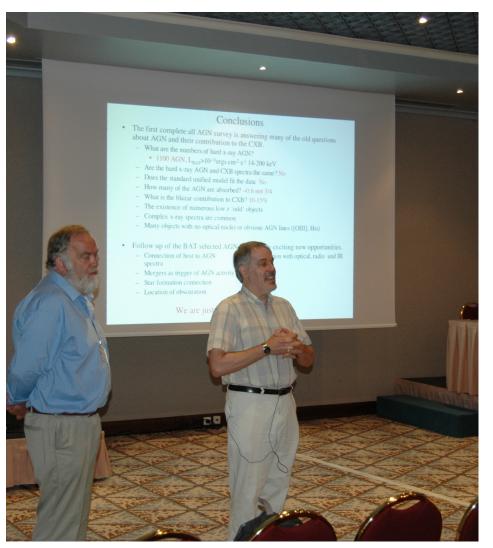
If the next SWG meeting is indeed March 18,19 it will be very difficult (but not impossible) for me to attend. With the launch of Astro-D now scheduled for Feb 20, I plan to leave for Japan on or about March 18 so that I can be there during instrument turn-on....

## XMM FAX List-1992 Technology of the 1990's

- J. Bleeker,, Utrecht 30-540860
- B. Brinkman,, Utrecht 30-540860
- P. DeKorte Utrecht 30-540860
- B. Aschenbach MPE ,Garching 498932993569
- J. Bergeron CNRS/Paris 33-140512100
- G. Bignami Milano 39-223-62946
- M Cropper MSSL 44-483-278312
- K. Mason MSSL 44-483-278312
- D. Lumb Penn State
- R. Willingale Leicester 44-533-550182
- R. Pallavicini Firenze 39-55220039
- G. Villa Milano 39-223-62946
- R. Griffiths STSCI
- Tone Peacock ESTEC 31-1719-84690

No internet, no cell phones, had to get permission from GSFC for international calls and faxes, no zoom, skype etc

Very different way of working, emphasis on e-mail and personal contact





Mike Turner SSC Chair

Rich Griffiths Mission Scientist

## Official Story

- Approved into implementation phase in 1994, and an improved observing efficiency achieved with a highly eccentric orbit which allowed the number of telescopes to be reduced.
- The development of suitable mirrors involved parallel studies of solid nickel, nickel sandwich and carbon fiber technologies up to early-1995.
  - Soon afterwards the nickel electroforming replication technology was adopted, following the delivery of two successful mirror module demonstration models.
- The XMM flight model mirror modules were delivered in December 1998.

## **Unofficial Story**

- The decision to drop from 7 to 3 telescopes and thus the deep orbit was forced on the SWG by a 'lie' from the ESA cost estimators
  - I later learned that this was due to the inability of the nation states to afford 7 focal planes
- The project focused on carbon fiber due to its light weight (which let the A-IV be the launcher). Major technical issues were hidden from the SWG: the mirror presentations were 'Kafka-esque'-
  - then a miracle occurred (thanks R. Laine project manager), we switched to Ni electroformed optics and the Ariane-V launcher

## Some forgotten moments

- Late in the development of the mirror (late 1995) B. Aschenbach discovered that it had a significant stray light problem due to the design
- He outlined the strong impact on science and the SWG supported the changes in design and the collimator was built and installed !!!

#### What Does a Project Scientist Do? 1995

Dear Keith,

I am writing to you in my role as U.S. XMM project scientist. As you may or may not know several years ago George Newton, when he was in control at NASA Hdqtrs "zeroed out" the prelaunch XMM software effort for both the optical monitor and the grating. Part of this was due to the inclusion of "science" in the prelaunch software budgets, part due to confusion in the budgets about which members of the team (U.S. and European) were doing which software and when and part due to the unclear separation of "necessary" prelaunch software efforts for calibration, integration etc. with "science" pre-launch software. Three years ago I said that we would re-visit this at the appropriate time that is now.

In order to be able to justify either a re-programming of U.S. funds or the request for additional funds I need to have a relatively secure justification. Could you please develop, in conjunction with your U.S. Co-I's, a plan for the U.S. provided "necessary" pre-launch software which is not presently being funded? I would like to have both a "minimal" and a "desirable" level of effort and an estimate from the U.S. co-I's of the budget implications. We have a "reasonable" post-launch data analysis budget for the U.S. teams (equivalent to 2-3 post-docs per team) and I want to make sure that we can get the best science out of the overall investment, both European and U.S. in the mission.

I do not want to get ESTEC involved as of yet because of the present confused situation involving the ESTEC manpower budget and the sensitive negotiations with the Science Survey Consortium that are presently underway. The desirable outcome for this exercise is the justification for the hiring of a few scientists by each hardware team who will be involved in the pre-flight software and calibration effort such that they will be able to make good use of the instrument after launch and be able to provide good technical input to the US guest observer facility.

Yours
Richard Mushotzky,
U.S. Project Scientist

## Launch-Dec 1999

In one of many mistakes, I chose to go to an AstroE1 pre-launch meeting rather than XMM launch



B. Brinkman

#### End of the SWG

- In 2002 ESA made the decision that the SWG would be 'disbanded' and replaced with a user group
  - Jürgen Schmitt Chairman
  - Phil Charles
  - Xavier Barcons
  - Andrea Comastri
  - Michiel Van der Klis
- The mission scientists were 'grandfathered' into the user group

## Important People

Arvind Parmar Mission Manager (2006-2012) Keith Mason OM PI





Fred Jansen- Mission Manger for Life

## Issues at Last SWT Meeting 2002

- Difficulties in commissioning OM modes (software is easy.... said Keith Mason)
- High background-low initial efficiency
- Pipeline processing delayed by ~1 year
- Mission planning issues
- SAS has major issues
- (Noticed that consumable lifetime is ~20 years)

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#### XMM GO Program 2002 \$5M for US GOs

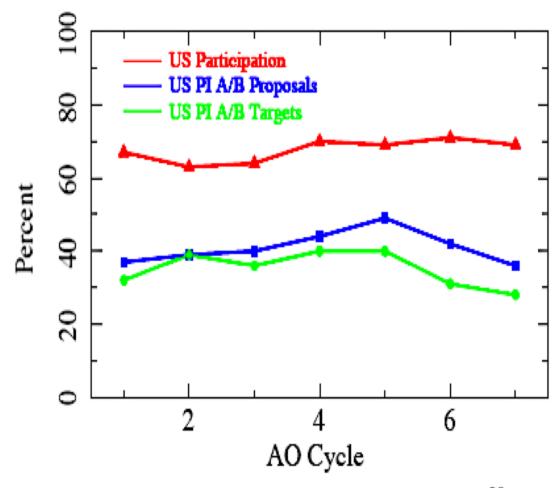
- The primary goal of the US XMM-Newton GO program is the support of US-PI investigations,... ~\$4.4 M .. will be allocated to ~90 US-PI proposals with ~\$0.6 M ...to support the participation of US Co-Is in foreign-PI investigations (~60 accepted proposals)
- However sometimes (often) NASA made it hard:
- Status report #78 July 2002
- 1) Funding of AO-2 proposals with recent observations

  Due to a change in the financial management system at GSFC, we have been unable to process grants since mid-May. With a successful transition to the new system, we expect to begin processing grants in the next week or two. We will reduce the backlog as quickly as possible

\$5M in 2002= \$6.87M 2019

#### Senior Reviews

- XMM entered the senior review process in 2000 without any public data
- But XMM did very well
- US community was and is a major user of XMM



#### Some GOF Activities

- The AO-1 &2 proposal submissions were chaotic using the ESA software
  - the US GOF supplied the Rosat/ASCA tested RPS system which ran smoothly for many years
- Steve Snowden and Kip Kuntz developed background subtraction software
- The GOF performed much testing and debugging the very buggy SAS the first few years of the mission (its always a holiday somewhere in Europe)



#### GOF Members-Steve Snowden head

- Ilana Harrus France
- Martin Still- UK
- Randall Smith
- Stefan Immler- Germany

Lynne Valencic





Software: Mike Arida Brenden Perry



# XMM-Newton Senior Review Presentations

- XMM Newton is a major joint ESA-NASA X-ray astronomy satellite with ESA responsible for construction of the satellite, mission operations and data processing, ESA nation states were responsible for the instruments
- ➤ 2 US groups have made substantial contributions to the instruments (Columbia Univ. S. Kahn PI for the reflection grating spectrometer (RGS), UCSD F. Cordova PI for the optical monitor (OM)
- The US guest observer program is supported by the guest observer facility (GOF) at Goddard Space Flight Center (R. Mushotzky US Project Scientist). This is also the site of the US archive
- More than 100 papers accepted in refereed journals so far.
- XMM is in its operational phase with most of the data going to the guest observer community worldwide

# XMM-Newton mission status



#### o Spacecraft status:

o All components operating nominally, except 2 RGS CCDs.

o No major degradation to the instruments. CTI increasing as expected (> 10 y lifetime).

o Orbital science efficiency ~ 70%.

#### o Ground segment:

o Major operations and software problems are now solved.

o Analysis software SAS v5.3 is comprehensive, robust and fast.

o Calibration within ~5-10%.

#### o <u>Proposal update:</u>

o AO-2 review in 2002 June. Results in July.

o The AO-3 deadline will be 2003 March.

#### o Data flow:

o Archive opened in 2002 March. 356 data sets available now.

o Data processing & delivery:

o 49% delivered in < 25 d

o 77% delivered in < 45 d

o Total delivered data sets:

o 437 GO (10.2 Msec)

o 585 GT (14.2 Msec)

#### US Participation in XMM 2002

- HARDWARE RGS (Columbia U) OM (UCSB, Sandia, LANL)
- SOFTWARF 1 GSFC programmer at the SSC
- 1 systems manager and 1 programmer at GSFC, user support and general analysis tools
- **SUPPORT** GOF (at NASA/GSFC) 3 scientists E/PO (GOF and UCSB)

SCIENCE AO-1: US astronomers on 66% of accepted proposals in AO-1 ~50% proposals have US PIs

(131 proposals)

364 US astronomers 408 targets

9.1 Ms of observing time

Full range of science areas

AO-2: ~870 total proposals submitted-9.5 times over subscribed (859 submitted to HST in last cycle)

~1/3 with US Pi's

1/4<sup>th</sup> of all active astronomers worldwide participated in Cycle 2 of **XMM-Newton** 33



## Visibility of *XMM-Newton*Results-2009



- Papers Published in Nature, Science, Astrophysical Journal, Astronomy and Astrophysics, Astronomical Journal, etc.
- Over 300 Refereed Publications per Year, > 1/3 with US Lead
   Authors
- US GO Funding Supported Refereed Publications Well Cited
   For papers from the last two years (GO funded projects)
  - 48% Belong to the Top 10% category of cited articles
  - 10% Belong to the Top 1% category of cited articles
- Complete Mirror of ESA Archive
  - 8998 Public Data Sets
  - 2.2 Tb of Storage
  - 160 Tb per Month Downloaded

#### On the Way Down

Major Changes Since Last Senior Review -2009

#### Reductions

- •Cut last hardware team (Columbia Univ) from 1.5 to .5 FTE (\$285 TO \$62K)
- •Reduced GSFC GOF by 0.5 FTE
- •Hdqtrs reduced GO budget from 2006 senior review budget by \$0.8M for FY 2008, \$1.0M/yr for FY 2009, \$0.6M for FY 2010.
- •Reviewed by Space Sciences Board (SSB) of the National Research Council (NRC) in the "Portals to the Universe" report. GOF Fully supported the review (RM testimony, + local interviews)

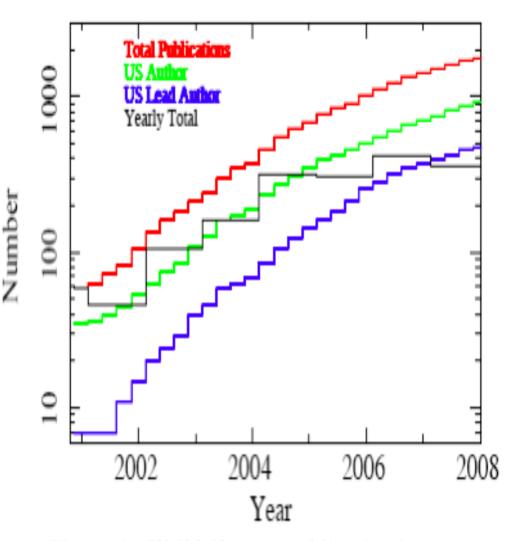


Figure 1: XMM-Newton publication history.

 XMM-Newton papers are four times more cited than the average astronomical paper, e.g. 7.8% of the XMM-Newton papers of the last year belong to the 1% most cited papers.

#### **Disaster** Senior Review 2009

- After coming in top or close to the top for 4 senior reviews in a row,
   XMM, for reasons that made no sense to me, got cut drastically
  - "XMM fared poorly, coming in 7th place (out of 10) behind WMAP."
    - the XMM GO budget will be zeroed out in FY 2010 and the GOF budget reduced-the impact of these cuts to x-ray astronomy will be severe, since the cuts represent a 30% reduction in funding to all x-ray GOs and occur in a step function
- The decision based on "funding US missions to keep operating was more important than funding GOs for foreign missions" ... I strongly objected to the science ranking of XMM
- (I believe that part of this was the extreme confusion at the time about full cost accounting and what XMM actually costed)
- As Project Scientist I took responsibility- this helped me make the decision to take the excellent offer from U of Md.

#### RM-XMM Science

 Dear Richard, The probability that your observations are scheduled within the next days is quite high, although I don't want to commit to anything, since the scheduling is strictly driven by aspects of optimization.

With best regards,
Michel G. Breitfellner
XMM-Newton User Support Group

 64 papers, ~3600 citations, 2 Phd Thesis (Lisa Winter ,DJ Pasham one Hubble, one Einstein Fellow) not too bad....

## US Users group

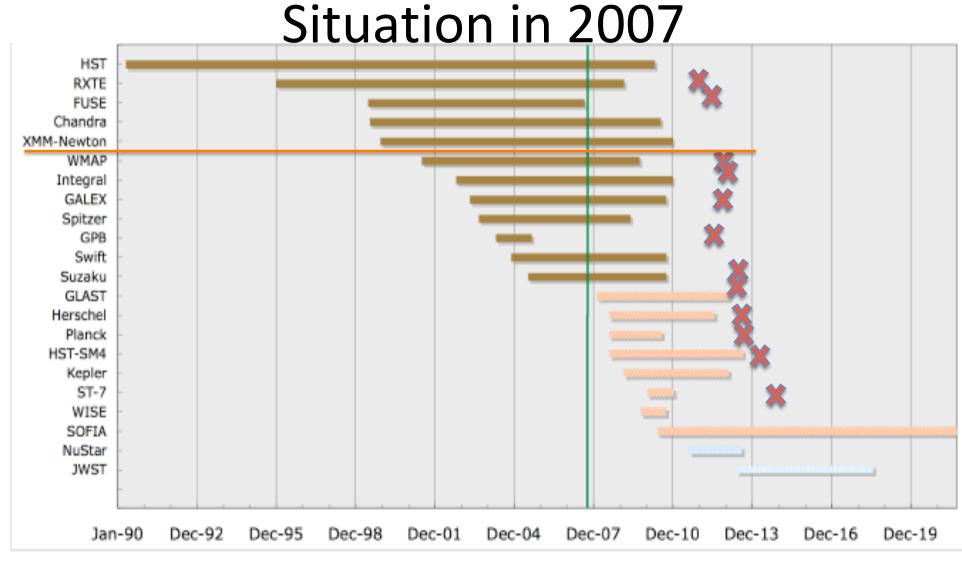
#### First members 2002

- Smita Mathur
- Dave Sanders
- Fred Walter
- Pat Slane
- Wilt Sanders
- Ann Zabludoff
- Chair Richard Griffiths



## XMM-Newton US Users Group 30 April 2007

02 03 04 05 06 07	8:00 8:30 8:35 8:50 9:20 9:35 9:50 10:00 10:10	Arrival and Snowden Mushotzky Sanders Snowden Perry Smith Smith Smith	Breakfast (sort of) and Meet and Greet Welcome – Agenda Introduction and Quick Mission Status The View from NASA HQ Activities and Status of the GOF Status and Future of SAS XMM-Newton Publication Tracking Status of the RGS Status of the Profit
	10:20	Cof	fee Break
09	10:50	Shafer	Status of the OM
	11;00	Snowden	Status of EPIC and Background Modeling
	11:20	Arida	Status of User Support and Archive
12	11:30	Cominsky	E/PO
13	12:00	Mushotzky	Budget Issues
	12:15	Lunch	Sandwiches Brought In
14	13:00	Snowden	Budget Considerations
15	13;05	Sanders	Budget Review Instructions
	13:20	Griffiths	Discussion of GO Budgets
	15:30	Griffiths	USG Closed Session (with Coffee)
	16:30	Griffiths	Further Questions and Answers ´
	17:00	Close	39

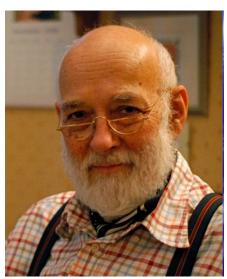


 XMM is a survivor: of 20 missions alive or planned in 2007 only 8 are left

#### In Memoriam

- Nani Bignami- first PI of EPIC
- Martin Turner- second PI of EPIC
- Roberto Pallavicini- Mission Scientist





## End of My Role

- I left GSFC became a Prof. at U of MD 2009
- new project scientist was required and <u>Steve Snowden</u> took over and performed admirably in that role
  - I hung on as a user group member for 8 more years
- I was a member of the user group for 15 years and people having decided that someone else needed a chance I was 'retired' in 2017.
  - quite sad: no more 2 day trips to Vilspa or ESTEC; no more worries about funding, NASA full cost accounting, senior reviews, US/ESA politics....



